CORUNDIFEROUS NEPHELINE-SYENITE FROM EASTERN ONTARIO

A CONSIDERABLE area of nepheline-syenite was discovered about six years ago in Dungannon township, Hastings county, Ontario, by Dr. F. Adams, who described the rock briefly in his "Report on the Geology of a portion of Central Ontario," and more fully in the *American Journal of Science*.[1] In 1896 corundum was found in the same region by Mr. W. F. Ferrier, and in the following year Professor W. G. Miller was instructed by Mr. Archibald Blue, director of mines of Ontario, to examine and report upon the corundum-bearing rocks. In the course of his work it was found that the corundum occurred not only in ordinary syenites but also in nepheline-syenite.[2] In November 1898 the present writer examined an outcrop of the latter rock for the Bureau of Mines on York branch of Madawaska River at the northeast corner of Dungannon township or just within Carlow, several miles from Dr. Adams' localities, and presenting a number of new and interesting features.

The rock forms a ridge running nearly north and south for about 350 yards with a width of about 20 yards, and having a well defined schistose character, so that at first sight it would be called gneiss. It is light to dark gray in color, the darker layers containing much biotite, the lighter ones more nepheline and plagioclase. On much of the weathered surface numbers of small crystals of corundum stand out, having resisted weathering better than the other constituents. In hand specimens of the unweathered rock, however, the corundum is scarcely noticed, and the rock has quite the appearance of fresh gray gneiss, the nepheline looking like quartz.

[1] Geol. Surv. Can., 1892–3, Part J, p. 5; Am. Jour. Sci., Vol. XLVIII, July 1894, pp. 10–18.

[2] Bur. Mines, Ont., Vol. VII, pp. 210–212.

Near the southern end of the ridge an irregular dike a few feet wide crosses the gneissoid rock, reminding one of pegmatite. It is white and consists of immense individuals of nepheline and muscovite, often several inches or even a foot long, with small patches of blue sodalite. No feldspar was seen in the dike, unlike examples described by Adams,[1] and no corundum was found in it.

As usual in nepheline-syenites there is great variation from point to point in the rock, easily seen on weathered surfaces and still more marked in thin sections. Adams finds, as essential ingredients of the outcrops near Bancroft, nepheline, plagioclase, and biotite or hornblende in small amounts; but scapolite and calcite usually occur, as well as various minor accessory minerals. Thin sections from the locality here described show more variety in constitution. All the minerals mentioned, except hornblende, occur, and the feldspars include orthoclase and also a little microcline as well as microperthite. The soda-lime feldspars are generally present in much larger amounts than the potash feldspars, and seem to have a wide range in composition as determined by optical means. A few have angles of extinction of 4° or 5° from the twin plane and appear to be albite as in the rock examined by Adams, others having a very small angle are probably oligoclase, while a considerable number range from 17° to 23° indicating labradorite. Some have broad and sharply cut twin lamellae, others very narrow and obscure ones. All the feldspars are beautifully clear and fresh as a rule, much more so than those of the associated Laurentian gneisses and granites.

The nepheline also is generally very fresh and, as mentioned by Adams, has not the color nor oily luster of eleolite, though it seldom shows crystal forms. Large individuals often contain inclusions, minute crystals of hornblende, of biotite, and long rows of tiny dots of a transparent doubly refracting mineral. Calcite inclusions sometimes occur completely enclosed in fresh looking nepheline. In one example the somewhat weathered nepheline contains crowds of slender transparent fibers or

[1] *Ibid.*, p. 11.

somewhat bent cords, having a little the look of apatite but with a small angle of extinction, perhaps tremolite. Occasionally decomposition products occur along fissures, having the appearance of kaolin but without any distinct structure.

Scapolite is found in about a third of the sections, sometimes almost to the exclusion of other colorless ingredients and has the look of a primary mineral. Its anhedra meet the adjoining feldspar or nepheline in a sharply defined way with no hint of weathering in the latter minerals. Muscovite is a very common constitutent of these rocks, being found in more than half of the thin sections examined, generally as large primary looking individuals, sometimes associated with biotite though often without it. Biotite is practically the only dark mineral in the rock, hornblende not having been observed. As in the specimens examined by Adams, it is very dark in color and has a very small axial angle. Augite was found as small blue-green anhedra in one section only. Magnetite was not found, and apatite was rare.

The most interesting accessory mineral is corundum, which sometimes occurs in fairly well formed barrel-shaped crystals half an inch in length, but is usually smaller and often forms only minute rounded grains. Its color is gray or less often pale bluish. Owing to the hardness of corundum it was found difficult to prepare sections rich in crystals and only two have been studied. Under the microscope their high refractive index and greater thickness than the rest of the section cause the corundum grains to stand out sharply. They are apt to be arranged in clusters in association with muscovite, often completely enclosed in it.

Although the rock here described has a well marked schistose structure, there is nothing in its microscopic characters to suggest shearing or crushing, no mortar structure nor granulation, and seldom even undulatory extinction to hint at a state of strain. The rock as a whole is hypidiomorphic granular, and except corundum none of its constituents show much tendency to crystalline form.

The coarse-grained dike with its individuals of nepheline half a foot wide is not easy to study in thin sections. The nepheline proves under the microscope to have been slightly fractured, very narrow fissures being filled with a rather brightly polarizing mineral, perhaps feldspar. The few inclusions are much like those of the nepheline in the schistose rock, but in one section rather large portions of muscovite are enclosed. The large crystals of pale lavender muscovite have no unusual characters except their often perfect idiomorphy as against nepheline and sodalite. The crystals are not hexagonal in cross section but four sided having one angle of about 60°. The basal cleavage is somewhat inclined to the prismatic edges, though a series of pyramids having a very long C axis makes it difficult to determine the angle. In thin sections cut across the cleavage this muscovite has an extinction angle of 3° to 5°.

If single thin sections were to be diagnosed alone four quite distinct types of rock could be described from this outcrop; a nepheline-muscovite rock; a rock made up chiefly of scapolite and muscovite with a little biotite, plagioclase, and nepheline; a rock containing about equal parts of plagioclase and nepheline with some mica; and a rock consisting of orthoclase, microcline and nepheline with some mica. There are, however, transitions between these varieties, and it would be unwise to split up what is so evidently a geological unit into rocks of different names when the whole is so well defined in general character, though each hand specimen shows differences from its neighbors.

No analysis has been made of this rock, but one specimen yielded nearly 10 per cent. of corundum in a heavy solution. As there was no magnetite nor other heavy mineral present the separation was very complete, corundum having a much higher specific gravity than the other ingredients. Since every mineral present, except the trifling quantity of calcite and apatite, contains alumina, nepheline in particular to the extent of more than 30 per cent., this oxide must occur in very large amounts. On the other hand iron oxides must be very low, since the only iron-bearing constituent is biotite.

A specimen of nepheline-syenite was obtained from Lancaster's farm, some miles west of the locality just described, from a small outcrop showing no schistose structure. It is coarser grained, but of the same color and general appearance as the rock from York branch. Thin sections show, however, that it has been subjected to shearing forces, since there is a granulation round the larger pieces of feldspar and nepheline suggesting mortar structure. Nepheline is present in large amounts and also a peculiar type of microperthite having long fibrous looking inclusions of one feldspar in another. the main mass being in parts very finely striated (anorthoclase?) with twin lines making an angle of about 23° with the most marked cleavage. Oligoclase and biotite occur in smaller amounts, the latter as usual very opaque. Some of its outer scales weather to a bronze-brown color, are dichroic, and have the optical axes much farther apart than in the fresh mica.

Specimens of a medium-grained white rock dotted with darker minerals come from a locality not visited by the writer, in Methuen township, Peterboro county, and are interesting as containing many dark brown corundum crystals having a bright bronze luster on basal partings, as well as minute crystals of magnetite.

Thin sections of one specimen disclose chiefly plagioclase, finely striated and with a low angle of extinction from the twin plane; a little microcline, nepheline and muscovite making up the rest of the rock. Sections of another specimen very similar in appearance contain more muscovite and a large amount of nepheline, or rather of a turbid decomposition product, confusedly scaly or fibrous, having high double refraction. The mineral seems to have parallel extinction, fuses readily without intumescence to a white glass, and gives water in the closed tube, so that it is no doubt a uniaxial or rhombic zeolite, perhaps natrolite. The corundum is very opaque so that only minute particles of crushed crystals can be studied satisfactorily. It contains many inclusions of two kinds, slender black needles lying parallel to one another, and brownish-red strips and plates

somewhat irregularly shaped and placed. The latter are probably hematite and produce the bronze luster seen on basal planes of the corundum. Extinction is parallel to the needle-like inclusions, and there is a rather strong dichroism, violet when the needles are parallel to the chief section of the lower nicol and reddish-brown in the opposite position. Some fragments, no doubt parallel to the basal plane, are not dichroic.

The first of the two specimens might be named a plagioclasite (anorthosite contains a more basic feldspar) if taken separately, but the second does not differ from typical examples of the York branch nepheline-syenite except in the complete weathering of its nepheline, and probably both are varying forms of the same rock mass.

Through the kindness of the director of the Bureau of Mines specimens of corundum rocks from Raglan township in Renfrew county, about twenty miles northeast of Dungannon, have been placed at my disposal. One is white, somewhat schistose, and much like the Methuen specimens except that it contains biotite, and that the pale greenish corundum crystals are almost an inch in diameter and have no bronze shimmer on basal planes. Under the microscope it is found to consist mainly of plagioclase (oligoclase) and biotite, the latter pale greenish-brown, faintly dichroic and with a small axial angle. There are also a few large patches of colorless muscovite having a large axial angle. The specimen has the mineralogical composition of a diorite, though of a very unusual character; but Professor Miller states that nepheline-syenite occurs close by, apparently part of the same rock mass, though not so highly corundiferous.[1]

These white rocks were taken for limestone by farmers of the region, and an attempt was made to burn them for lime, of course, in vain. Hand specimens, partly fused, were taken from the kiln and supposed to be nepheline-syenite, many of them doubtless having that composition; but the one provided for microscopic examination contains no nepheline. It is evidently part of a bowlder and is schistose and pale gray to white on the

[1] Bur. Mines, Ont., 1897, p. 222.

surface, but mottled bright blue and white where broken. Under the microscope the rock is found to consist of scapolite, sodalite and biotite with a very little orthoclase. The scapolite forms the greater part of the rock, the spaces between its anhedra being filled with sodalite; the latter blue throughout when in small portions, but only on the edges when in large ones, the center being colorless and isotropic. The bowlders are said by Miller to be blue only after being burnt in the lime-kiln.

The biotite is deep red-brown in color, has a high absorption and a wide axial angle, perhaps the result of heating; just as many dark biotites turn brown by weathering and have a wider angle between the optical axes.

There are small quantities of an unknown mineral present, white, transparent and having a low double refraction, so as to give only dull blue or purple tints between crossed nicols. Two or three sections of it show an axial image consisting of a black cross opening out about as far as in many biotites, but without colored rings. It is optically positive.

About eleven years ago the writer collected a considerable number of specimens of nepheline-syenite from drift bowlders in the neighborhood of Cobourg, Ontario, which lies about south-southwest of the localities referred to above and from fifty to a hundred miles distant from them. At that time nepheline-syenite had not yet been reported from the province.[1] In a general way these specimens correspond in appearance and composition to those that have been described, though a number of additional minerals occur in them, the more important being hornblende, augite and garnet, both of the ordinary kind and melanite, the brown variety. Only one of the specimens collected then contains corundum; and it, though closely like the others in appearance, shows little or no nepheline and resembles in mineralogical constitution, one of the specimens from Methuen. The purplish-gray corundum crystals are quite large, and thin sections show the same needlelike inclusions

[1] Trans. Roy. Soc. Can., 1890, pp. 14–18.

and dichroism as the Methuen crystals, but not the hematite plates.

As there is not much doubt that the Cobourg drift bowlders originated in the nepheline-syenite region to the northeast, they have been referred to here and may be considered in connection with the rocks previously described.

In spite of the great variations in mineralogical composition to be seen in hand specimens all the rocks referred to have much in common; they are white to gray in color, generally schistose, often corundiferous, and present the same general habit, so that in field work they are naturally thrown together as nepheline-syenite and can be sharply distinguished from adjoining Laurentian gneisses, granites, and syenites. While not all of them contain corundum in large amounts they serve as a general guide to the discovery of the corundiferous rocks and are so used by prospectors for that mineral. Some of the ordinary syenites of the region, however, contain corundum also, and the largest crystals found occur in them.

Just why the magma which has solidified into the group of rocks described above should be so versatile in regard to mineralogical composition is not easily explained; but no other rock known to the writer shows so great a variety of types within short distances as may be found in the nepheline-syenites. It may be that experiments such as those of Morozewicz[1] will give the clue to this variability, which seems to depend on the large proportion of alumina in the original magma. The corundiferous varieties of nepheline-syenite represent magmas supersaturated with alumina but not saturated with silica.

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[1]See Review by T. A. JAGGAR: JOUR. GEOL., 1899, Vol. VII, No. 3, pp. 300, etc.